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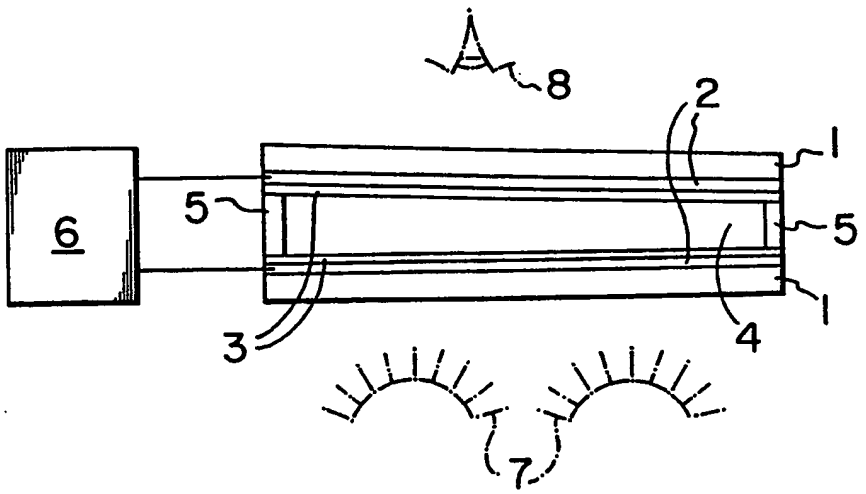

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(57) Abstract

In this invention a time-varying or a fixed-value quality is displayed on the two dimensional face of a new electro-optical cell. This cell can be utilised in flat panel displays which presently employ either one of the several types of Liquid Crystal cells operating in a variety of modes, or which employ Electroluminescent, Plasma Discharge, Electrochromic, Electrophoretic, Display Suspension, Fluorescence Activated or other cells well known in the art. Presently such cells consist basically of two parallel electrode structures deposited or attached to plates which form the walls confining an electro-optical compound. The distinctive feature of this invention which is applicable to all cells mentioned in the foregoing, is the non-parallel or slanted orientation of the two electrodes and of the plate surfaces on which they are deposited, with respect to each other. The resulting variation of the spacing between the electrodes across the cell varies the electric field and thus the distribution of lighted areas on the face of the cell. This distribution is also a function of the applied voltage to the electrodes and the voltage waveform. These effects can be used in simple forms of meters, indicators, monitors and in animated displays for advertising and signage, toys and games.

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AN ELECTRO-OPTIC CELL FOR ANIMATED DISPLAYS AND INDICATORS

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Background of the Invention

1) Field of the invention

This invention relates to meters, monitors and indicator instruments designed to measure or to indicate a voltage or another physical quantity that can be displayed in the form of a voltage. It also relates to animated displays used in signage advertising, merchandising and instructional fields designed to illustrate the movement of images or flow of air, liquids, matter or energy, graphically depicted on a front-or backlighted screen or in projection. It is related to liquid crystal, electrochromic, electrophoretic, dipole suspension, ferro-electric, electroluminescent, Plasma Discharge and other flat panel displays which are designed to selectively illuminate and/or animate areas on a screen. This invention is based on a novel and simple structure and design of an electro-optical cell, for example a liquid crystal cell, that permits conversion and the display of a time dependent variable as a spatial coordinate variable on a two dimensional screen. The indicating or metering function and/or the animation effects can be achieved by simple means and can include linear, curved, pulsating accelerating decelerating, blinking and wavelike effects, and the effects can be limited to the parts of the display screen of interest. Information in form of pictures, artwork, symbols, letters, alphanumerics that is fixed or changed as a function of a measured quantity can form a part of the animated display. It can also form a separate display device such as in an indicator, meter or monitor of any physical quantity that may or may not include an animated symbol such as an arrow to draw attention. This invention also relates to coloured displays animated and/or stationary in which the control of the hue or saturation of the colour is obtained through the interaction of polarised light with a chromatic polariser or optical retarder.

2) Description of Prior Art

In the prior art meters, monitors and indicators were often based on the electrodynamic or the electrostatic mechanism many forms of which were invented by Faraday, Kelvin, Harris, Weston and others in the 19th century. The electrodynamic mechanism is based on the rotation of a current carrying coil placed in a magnetic field. The electrostatic mechanism is based on the torque resulting from the attraction between a fixed and movable plate when a voltage is applied between them. Both these mechanisms, designed for the purpose of measuring electrical quantities, require moving parts. In this invention the indication and/or measurement of a voltage or another derived quantity is accomplished in a novel structure of an electro-optical cell, such as in that of a liquid crystal cell; and do not have any moving mechanical parts.

In the prior art animated displays have been generally characterised by the presence of a light source, a ratable polariser, manually or motor driver interacting with another set of polarisers. One such display device is disclosed in the patent by Yates and another, which might be considered an improvement on the former, is disclosed in the patent to A. Siksal, cited. Both show a motor driven polariser disc being an integral and necessary part of the system. In the prior art devices capable of selectively illuminating parts of a dark screen, using the light polarisation phenomena applied to indicators or advertising panels, also relied on rotating parts as disclosed for example in the patent to Dreyer. In the prior art production of animated colour effects or selectively illuminated coloured parts on the viewing screen has been obtained by placing suitably oriented and shaped birefringent or dichroic plastic material between two polarisers (the second being often referred to as the analyzer), one of them being usually a motor driven polariser disc. An example of such a display is disclosed in the patent to Burchell.

The presence of mechanical often motor driven parts in the prior art indicators and displays, discussed in the foregoing, gives rise to a number of undesirable side effects. In addition

to the bulky design and wear and tear, that calls for regular maintenance, it is sometimes necessary to control noise, vibration and heat generation due to the operation of an electric motor. Also, since a rotating disc is usually circular in shape and the display panel usually square or rectangular, a common problem arising is that of illuminating the corners and edges of the panel with rotating polarised light. Additional pulleys and discs have to be provided for the corners; they do not solve the problem completely and add to the complexity of the design. Although the speed of the motor is controllable, it cannot be changed quickly enough to produce certain desired animation effects. The range of possible animation effects could be greatly enlarged and the process could be simplified were it possible to animate individually the desired portions of the display. However the speed of the motor in such displays often determines the rate of change of the animation effects throughout the whole display panel. Some aspects of these limitations have been overcome and disclosed in the patent by Makow and further advantages and simplifications can be obtained by the present invention.

In the prior art multiplexed liquid crystal and other displays have also been used having a grid-like column and row structure of the electrodes. These electrodes were excited from the output of a electronic circuit or computer programmed to display alphanumeric, or animated image information. Also in the prior art indicator or animated displays have been used that comprise a large number of light emitting diodes placed side by side in columns and rows and individually excited from suitable electronic circuit or computers. In both the multiplexed liquid crystal and light emitting diode designs such systems are relatively complex and expensive for the applications mentioned in the foregoing. These limitations can be overcome and a number of advantages and new effects can be realised by the present invention.

Summary of the Invention

1) Brief Description of the Drawings

The drawings which illustrate the principles of the embodiments of the invention, may be modified and changed as regards the immediate illustration, all within the true intent and scope of the invention, hereinafter defined and Claimed.

Figure 1 is a cross section of the basic embodiment of the invention showing slanted confining walls of the electro-optic cell for viewing in transmitted light.

Figure 2 shows the embodiment of the invention of Figure 1 in addition comprising a reflector for viewing in reflected light.

Figure 3 shows the embodiment of the invention of Figure 1 in addition comprising two polarisers as used in a twisted or supertwisted nematic liquid crystal electro-optic cells.

Figure 4 shows the embodiment of the invention of Figure 3 in addition comprising an optical retardation plate and a protective, masking or image carrying transparent screen.

Figure 5 shows a plane view of a rectangular slanted cell, having the cross section shown in any one of the preceding Figures exited by a voltage $V_1 < V_x < V_2$ and the area A_x through which light transmission takes place.

Figure 6 is a plane view of the rectangular cell shown in any of the preceding Figures in which one of the polarisers or electrodes is shaped to form an arrow or is masked off by an arrow shaped image depicted on the screen.

Figure 7 is a plane view of the rectangular cell shown in any of the Figures 3 or 4 in which one polariser consists of a plurality of linear polariser sections assembled side by side and having different directions of polarisation.

Figure 8 shows one typical relationship between the intensity I of transmitted or reflected light in a twisted nematic cell, and the voltage V applied to its electrodes.

Figure 9 shows examples of waveforms of the voltage that could be applied to the electrodes of the slanted cell in order to produce an animated image effect.

Figure 10 is another embodiment of the invention showing

the cross section of a rectangular cell in which one of the glass plates with its deposited electrode is concave; thus the angle of the slant being variable and the spacing d_x being a nonlinear function of the dimensions of the cell.

Figure 11 is still another embodiment of the invention showing the cross sections of a rectangular cell in which one of the glass plates is shaped to provide a step-like discontinuous change of the slant angle and of the spacing d_x.

Figure 12 is a plane view of the rectangular cell shown in Figure 10 exited by a voltage $V_1 < V_x < V_2$ and the areas A_x through which light transmission takes place.

Figure 13 shows the plane view of a circular equivalent of Figures 10 and 12, in which at least one of the electrodes deposited on the glass plates is circular.

Figure 14 shows the embodiment of Figure 3 comprising an additional conventional twisted or supertwisted nematic cell and a chromatic polariser placed in the same optical path for the production and control of hue or saturation of the colour.

Figure 15 shows an embodiment of the invention to produce an animated image flow effect comprising of an assembly of slanted cells shown in Figures 3 or 4, placed side by side and an additional conventional twisted or supertwisted nematic cell placed in the same optical path with the assembly of slanted cells.

Figure 16 shows an embodiment of the invention to produce an animated image flow effect as in Figure 15, wherein the assembly of slanted cell has been substituted by a single slanted cell having separately excited sections of the electrodes.

Figure 17 shows a diagramic explanation of the animated image flow effect of the embodiment of Figure 15 when the slanted cells are excited by saw-tooth voltage waveforms and the conventional cell is excited by a square voltage waveform.

The above shown embodiments basically comprise the new slanted electro-optical cell alone or in combination with a reflector, retardation plate or screen or suitable polarisers to be used as a meter, monitor, indicator or an animated display or

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in combination with additional conventional cells to produce an animated image flow or colour effects. The operation of these devices and its possible variations of modifications will now be described in greater detail.

2) Description of the Invention

This invention utilises as its basic distinguishing element a novel form of a electro-optical cell. The conventional form that has been used to date in many displays mentioned in the foregoing consists of two confining parallel walls, at least one being transparent and made out of a glass or plastic plate. On at least a part of the inside surface of the walls there are deposited, or attached to, transparent conductive electrode structures. These are treated, coated, covered or attached to by layers of materials as required for the functioning of the cell. A suitable electro-optical compound is sandwiched between them. The compound is protected from the external environment and leakage by a seal around the edges of the walls. Such basic cell structures have been used as a basic element in liquid crystal (LCD), in electrochromic (ECD), electrophoretic (EPD) electroluminescent (EL), plasma discharge (PD) and dipolar suspension (DSD), and other displays. The sandwiched compound has been respectively a liquid crystal material, an electrolyte, a dyed suspending medium, phosphor, gas and dipoles in liquid suspension. Among the various types of liquid crystal displays such cell structure has been used as its basic element in Dynamic Scattering Mode (DSM), Twisted Nematic (TN), Supertwisted Nematic (STN), Fluorescent LCD's, Cholesteric-nematic LCD's, tunable birefringence LCD's, LCD's with external retardation sheet, Guest-host LCD's known as Dichroic LCD's. Dye Phase Change LCD's, Smectic A LCD's, Ferroelectric LCD's, Multiplexed LCD's and other recently proposed displays.

The common feature of the cell structure in the presently used displays mentioned above is that the confining walls are parallel to each other. In the proposed novel form these two walls with their deposited electrodes are non-parallel and are slanted with respect to each other at a small angle usually much

smaller than a degree. The slant angle can be also variable or discontinuous. All other features of the respective electro-optical displays remain the same. The slant of the walls introduces a new effect which permits the display of a time-dependent variable f(t) as a two dimensional space coordinate variable f(x,y) on the surface of the cell and on the attached to it screen.

The operation of the novel cell form to be referred to in the following as the slanted cell will be explained using the example of a conventional Twisted Nematic (TN) cell, being utilised in the majority of liquid crystal displays. Any other type of electro-optical display cell mentioned in the foregoing can be shown to acquire similar properties when their confining walls are slanted. This is the case wherever the respective electro-optical effect is dependent on the electric field strength. The structure and the function of the Twisted Nematic cells has been first described by Schadt et al in 1971 and has been since used widely in a variety of display applications. A brief description of this cell will facilitate the understanding of the slanted cell.

The conventional twisted nematic cell consists of the nematic liquid crystal Electro-optical compound confined between the two parallel glass plates sealed together at the boundaries. On the inside of the glass plates are deposited thin conducting transparent electrodes having the spacing d_o. On the outside of the cell, on the side away from the viewer, there is attached and parallel to the glass plate one first linear polariser and on the side facing the viewer, there is attached a second polariser rotated at a 90 degree angle with respect to the first one. The inside surfaces of the electrodes facing the compound are coated with blocking layer and then with an aligning layer to facilitate the parallel alignment of the liquid crystal molecules in the required relation with the direction of the respective polariser. In the presence of a zero or small electric field, that is when a voltage $V < V_o$ (V_o = threshold voltage) is applied to the electrodes, the polarised light is rotated by 90 degrees by the twisted molecular alignment and

emerges from the other side of the cell. When a suitable voltage $V = V_s$ (usually the saturation voltage V_s = 2 to 6 volts), giving rise to an electric field E_s is applied to the electrodes, the twisted alignment of the molecules is destroyed and the light which is linearly polarised by the first polariser is not rotated and thus is blocked by the second polariser is not rotated and thus makes a zero angle with the direction of the first polariser. In the alternative arrangement the second polariser is not rotated and thus makes a zero angle with the direction of the first polarizer. The results are then reversed. For intermediate values of the voltage $V = V_x$, where $V_o \leq V_x \leq V_s$, the twisted alignment of the molecules is not fully destroyed and part of the light is emerging, thus permitting a gray scale. In the case of a supertwisted nematic (STN) cell the alignment of the molecules can be as much as 270 degrees and more. The electric field E_S required to almost fully destroy the twisted alignment of the molecules is given, in the first approximation, by the ratio $E_s > \frac{V_s}{d_o}$ of the applied voltage V_s to the spacing d_o between the electrodes. Thus for greater spacings d_o, the voltage V_s has to increase to satisfy this equation.

The novel structure and new properties of twisted or supertwisted nematic cell and the other cells mentioned in the foregoing are obtained when one glass plate with the electrode deposited on it is slanted by a suitable small angle, in the direction of at least one spatial coordinate, with respect to the other electrode deposited on the other glass plate. Thus the electrodes are no longer parallel to each other, and have a spacing d_x that varies across the cell from the smallest value d_1, at the location x_1 to its largest value d_2 at the location x_2 (see Figure 4). The application of a voltage $V_x = E_S d_x$ to the electrodes, d_x being the spacing at the location x would result in transmission of light through the area A_x of the cell for

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which $d_1 < d_x$ (see Figure 5). This effect can be used in a new form of meter, monitor or indicator. In particular if the shape of the voltage is a function of time such as for example a saw-tooth waveform, (see Figure 9a), light transmission would be observed through the area A which is increasing from the area $A_1 = 0$ to the total area A_2 of the cell, as the voltage V_x of the saw-tooth waveform varies from V_1 to V_2. Thus a function of time f(t) is converted into a function of the coordinates x and y on the face of the cell. The change of the voltage is visualised as a movement of the illuminated area and can be used in novel forms of animated displays for signage, advertising, instructional and other displays.

The spacing d_x can be also a non-linear or discontinuous function of the coordinates x and/or y of the cell dimensions. This can be the case for example when the center of one confining wall with its deposited electrode is bent upward with respect to its edges (see Figure 10), or if there are steplike transitions between the smallest and largest spacing (see Figure 11).

It will be appreciated that depending on the shape of the voltage waveforms, different effects and forms of animated movement of the lighted area A_x can be obtained using a single cell. In order to obtain an animated continuous flow movement more than one cell will be required as will be explained later. Animated colour effects can be obtained by placing chromatic polarisers, retardation plates or additional cells with chromatic polarisers in the same optical path with the system described in the foregoing.

It will be apparent to a person skilled in the art that most of the previously mentioned drawbacks of mechanical elements will be eliminated using the described slanted cell. In addition, distinct advantages will become apparent such as complete freedom with regard to the placement of the animated details on the panel, including the corners and edges. Each detail could be animated from a separate electronic circuit at its own rate and speed or can be stationary or slowly changing

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to supply information only. Thus new effects and effect distribution and control, until now not possible, can be realised by such electro-optical means. These and other desirable objects and properties of the invention will become evident to a person skilled in the art as they are discussed in the following sections.

Description of the Preferred Embodiments

The basic embodiment of the invention is shown diagrammatically in Figure 1 for viewing in transmitted light and in Figure 2 for viewing in reflected light. Refinements of design which might be required, such as for example an enclosure, a transparent, protective, image carrying or masking sheet or screen, light directing or modifying means such like lenses or light diffusers or absorbers and the like, will be evident to people skilled in the art and may not be shown for the sake of clarity. The embodiment consists of a uniform suitable incandescent, fluorescent electroluminescent or natural light source 7 with or without a light diffuser, illuminating the cell on the side away from the viewer which will be referred to in the following as the interior side. The cell has two glass walls 1 at least one transparent and slanted with respect to the other at a small angle. On their inside are deposited or attached transparent conductive electrodes 2 out of, for example ITO or In_3O_2, which are connected to the voltage source 6. The electrodes are treated coated covered or have attached to at least one layer 3 of suitable material as required for the operation of the cell or protection of the surface of the electrodes. The walls are confining the compound 4 and the interior space is fixed by spacers and is sealed at the edges with the spacer 5 to prevent contamination and leakage of the compound 4. The compound 4 varies depending on the type of the cell, as discussed in the section summarizing the invention. The desired angle of the slant of one wall with respect to the other is obtained by using slanted separating spacers 5 at the boundaries of the cell or by glass or other transparent fibres or beads distributed uniformly across the cell and having a

progressively increasing or decreasing diameter. The cell is viewed from the side facing the viewer 8; this side to be referred to in the following as the exterior side. Such basic cell structure as shown in Figure 1 can be used for example in electrochromic displays (ECD). Here one ITO transparent electrode 2 can have a WO_3 layer 3 deposited on it, the second ITO electrode has a Pd layer charged with hydrogen. The internal compound 4 is an electrolyte with TIO_2. When the basic slanted cell is used in electrophoretic displays (EPD) the compound 4 is a suspension of TIO_2 charged particle in a black fluid. When used in Dipolar Suspension displays (DSD) the compound 4 is a suspension of dichroic particles. For the electroluminescent (EL) and plasma discharge (PD) displays the compound 4 is for example phosphor and neon-argon gas respectively. The same basic structure of Figure 1 has been used in Liquid Crystal Displays (LCD) where the conductive electrode 2, often out of In_2O_3 or ITO, is coated with a blocking and alignment layers 3 and the compound 4 is a liquid crystal. Depending on the type of the cell, as discussed in the summary of the invention, the compound 4 can be a nematic, quest host, cholesteric, cholesteric-nematic, smectic or a ferroelectric liquid crystal. Depending on the mode of operation one interior or one exterior or both polarisers might be added to the basic cell, and when viewed in reflected light a reflector is placed on the interior side of the cell.

For viewing in reflected light, for example in suitably illuminated rooms or in day light, the basic embodiment as shown in Figure 2 also comprises a reflector 9 placed on the interior side of the slanted cell. The reflector, well known in the art, can be opaque, semitransparent and may also comprise any one of the means to enhance, spectrally modify or diffuse the incident light. Such means may include suitably treated fluorescent or coloured foils made out of metals or other material, replacing or complementing the light source. The light source 7 is now on the same side as the viewer 8. All the effects described in the foregoing can be now observed in reflection as the polarisation

of light is not lost as a result of reflection.

Further preferred embodiments of the invention are shown in Figures 3 and 4 illustrating the mode of operation of a twisted or supertwisted nematic liquid crystal display. In Figure 3 the light is linearly polarised in the interior polariser 10 facing away from the viewer 8 and the plane of polarisation is rotated by 90 degrees or more in the slanted liquid crystal cell which comprises the transparent electrodes 2 with a blocking and aligning layer 3 deposited on the glass plates (1) which confine the nematic LC material 4. The rotated polarised light is emerging or is blocked by the exterior polariser 11 facing the viewer 8 depending on the orientation of the two polarizers with respect to each other. The voltage which is applied to the electrodes is generated in an electronic circuit, transducer or manual voltage controller, 6 the latter such as a variac or potentiometer to which the electrodes are connected to. In Figure 4 an image carrying screen 12 and a retardation sheet 13 are shown in addition to the parts shown in Figure 3. One or the other or both can be incorporated as an additional option. The slanted cell in Figure 4 has the two confining walls 1 with its deposited electrodes 2 and blocking and aligning layers 3. The slanted walls, as described previously, permit the display of a time dependent quantity on at least one space coordinate on the face of the cell. The angle of the slant and the spacing d_1 and d_2 of the electrodes at its minimum and maximum values respectively (see Figure 4) are in the first approximation linearly related to the respective voltages V_1 and V_2 required for maximum or minimum (depending on the angle of the two polariser directions with respect to each other) light transmission to satisfy the equation

$$E_s = \frac{V_1}{d_1} = \frac{V_2}{d_2} = \text{constant}$$

which occurs at the electric field strength E_s. In a practical case of a 2 x 6 inches cell the spacing required for d_1 and d_2 were about 8 and 12 µm (micrometers) for the voltages V_1 and V_2 of about 3 and 4.5 V or for another TN-LC mixture 12 and 18 µm

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for voltages of 4.0 and 6 Volts respectively. Figure 8 shows a typical relationship between voltage V and transmitted light intensity I of a TN liquid crystal cell when the angle of the interior to the exterior polariser direction is zero, thus the directions being parallel to each other. For smaller spacings d the maximum is reached at lower voltages V_s. Figure 9 shows examples of voltage waveforms that can be used to obtain various animation effects.

The embodiment or the invention shown in Figure 4 comprises in addition to the parts shown in Figures 1 to 3 an optical retardation plate 13 consisting of a solid birefringent sheet which permits the display of two complementary colours when the device is switched between the voltage values V_o and V_s, the colours being governed by the thickness of the sheet. Thus by suitable choice of voltages the animation or indicating effect can be combined with a colour change effect in order to evoke an enhanced alerting response In addition an image carrying screen 12 is shown in Figure 4, which can carry for example numerals, or symbols indicating a value, a condition a warning sign or an actual image to be animated. Figure 5 shows the light distribution across the face of the cell shown in Figure 4. Observe that light is transmitted through the area A_x, from the location x_1 corresponding to the smallest spacing d_1, to the location x corresponding to the spacing d_x for which the applied voltage V_x satisfies the equation $V_x = E_s d_x$. Thus the location x or the area A_x shown on the screen is a measure of the voltage V_x. This mode of operation can be used in the application as a voltage indicator, meter or monitor. Figure 6 shows the plane view of the face of the cell shown in Figure 4 in which the image carrying screen is masking off the face or the cell accept for a arrow shaped symbol. This symbol could be alternately obtained by shaping the exterior polariser or one of the electrodes in the same manner. Of interest is the animation of this arrow symbol which can be obtained by applying a saw-tooth waveform shown in Figure 9 graph (a), to the electrodes. As the voltage increases from the value V_1 towards the peak

value V_2, the area A_x through which light is transmitted will be increasing from zero to a maximum when the whole errow is visible, following which there will be a fast return to zero. This periodic reciprocating animation of the arrow symbol will help to draw the attention of the viewer as for example in the case of the direction indicator light of a car or traffic sign. The application of a triangular waveform to the electrode will result in a symmetrical increase and decrease of the errow size and the application of a square waveform will result in a blinking mode. Figure 7 shows an example of the exterior polariser consisting of polariser sections oriented at different directions of polarisation. These sections are assembled side by side and form a one layer polariser mosaic, which can also be obtained by an embossing process described by Siksai. The use of such a polarising mosaic makes it possible to incorporate additional gray scale effects. Here the transmission of light will be reduced in those sections whose directions differ from the direction of the plane polarized light emerging from the slanted cell.

In a further embodiments of the invention the spacing d_x is a non-linear function of the dimensions of the cell as shown in Figures 10 and 11. In the embodiment shown in Figure 10 the exterior wall of the cell with its deposited electrode is curved, for example concave. Following the same reasoning as in the description of the slanted cell it is evident that there will now be two areas A_x as shown in Figure 12 through which light transmission will take place as there will be two symmetrical locations having equal electrode spacing. These areas will move symmetrically towards the center with increasing voltage. A reverse effect can be obtained by reversing the polarity of the saw-tooth waveform or when the curvature of the exterior wall is convex. The curvature of the glass plate of the cell can be obtained by a variety of means such as for example by slightly bending the plate using a center post determining the spacing in the center of the cell or by shaping the surface of the glass plate with tools. A variation of a concave or convex shape of one wall is a V or an inverted V

shape which results in similar operational characteristics. The face of the same cell having a circular electrode, and a cross section that of Figure 10 is shown in Figure 13. The operation of this cell is analogous to that of the rectangular cell. The circular shape of the electrodes results in a concentric radial change of the area through which light is transmitted and will be found advantageous in certain indicator or animated image applications in preference to the unidirectional movement in a rectangular slanted cell. In the embodiment shown in Figure 11 the interior side of the exterior wall with its deposited electrode is shaped in a discontinuous stair-like manner. Following the same reasoning as in the foregoing it will be appreciated that this configuration will permit the display of the change of the area A_x in discrete steps.

In an extension of the basic embodiment of the invention colour can be introduced by the addition of at least one conventional TN or STN liquid crystal cell having parallel electrodes in combination with a chromatic, sometimes referred to as spectral polariser or in combination with a chromatic linear retarder, well known in the art (and described by Shanks and Shurcliffe, cited), which are commercially available. This permits the production and independent control of colour effects in an indicator or animated display using a slanted cell. In Figure 14 the upper portion of such an embodiment is similar to that of Figure 4 that produces the indicator or animation effects. It consists of the picture carrying screen 12, the slanted cell walls 1 with its transparent electrodes 2, energised and controlled from the output (a) of the voltage source 21 such as an electronic circuit transducer or manual voltage controller, the blocking and alignment layers 3 and exterior polariser 11. This upper portion receives plane polarised coloured light from the chromatic or spectral polariser 20 but its function is identical to the embodiment shown in Figure 4 without the retardation plate 13. The chromatic polariser 20 may represent a dyed linear polarizer which absorbs a part of the visible spectrum and thus produces coloured light in transmission. In such a case the change of

angle of the plane of polarised achromatic light entering such polariser from the conventional additional TN or STN cell, changes the saturation of the transmitted coloured light. The interior side of the chromatic polariser 20 is illuminated by the conventional additional TN or STN cell with its glass walls 19, deposited transparent electrodes 17, blocking and aligning layer 16, linear polariser 14 and nematic LC compound 18. The degree of saturation can be controlled electronically from the output (b) voltage source 21. The chromatic polariser 20 may also consist, of two dyed linear polarisers, say one passing blue light and the other red light, bonded together with their polarisation axis at 90 degrees to each other and forming one sheet. In such a case the change of angle of the plane of polarised achromatic light entering this polariser from the cell, which is aligned at 45 degrees to the direction of the dyed polarisers changes the hue of the coloured light. The hue of the coloured light can be thus controlled from the output (b) of the voltage source 21. The chromatic polariser 20 may also consist of a solid linear retarder plate of birefringent material and a linear polariser which in this case will also permit the control of hue in a manner as outlined in the foregoing. A still further method of controlling the colour of the emerging light is by substituting the said linear retarder by one or more layers of a birefringement film (such as polyvinyl alcohol film or cellulose film or polyvinyl fluoride film). It will be evident to a person skilled in the art that in addition to the slanted cell a serial assembly of said two conventional cell configurations described in the foregoing one controlling the saturation and the other the hue of the colour light will result in the control of both.

A still further embodiment of the invention comprises at least two slanted cells and a conventional cell having parallel walls in order to obtain a continuous flow-like image animation effect. An example of such an embodiment is shown in Figure 15 consisting of an assembly of 3 slanted cells 1, 2, 3 each having a structure as in Figure 4, but without the retardation plate 13 and the interior polariser 10, connected in parallel to the same

output (a) of the voltage source 22 which generates a saw-tooth waveform shown in Figure 9, graph (a). In addition, on the interior side of these cells a conventional large nematic cell but without its exterior polariser, having parallel electrodes 17, deposited on parallel glass plates 19 is placed in the same optical path with the three slanted cells; the electrodes being connected to the second output (b) of the voltage source 22 generating a square voltage waveform. An equivalent embodiment is shown in Figure 16 where only one larger slanted cell is used having three separate electrodes deposited side by side on the inside of the exterior wall of the cell and exited by three different voltages. The voltages are related to each other, in the first approximation, in the same ratio as the ratio of the electrode spacings at the center of each of the three electrodes.

The flow-like animation effect will be explained with the help of the diagrams in Figure 17, graphs (a) to (e) showing the plane view of the cells as a function of time and the graphs (f) and (g) showing respectively the voltage waveforms available at the output (a) and (b) of the voltage source 22. The graph (a) at the time t=0 shows the cells 1 and 3 transmitting light and appearing white while the cell 2 appearing dark as its exterior polariser is turned 90 degrees with respect to the exterior polarisers of the cell 1 and 3. The slant of the cells 1, 2 and 3 and the value and slope of the rising saw-tooth voltage shown in graph (f) are chosen so that at the time t=0,5 the first half of the cells 1 and 3 become dark and that of cell 2 become white as shown in graph (b). At the time t<1, graph (c), just before the drop of the voltage the cells 1 and 3 will be totally dark and the cell 2 will be white. At the time t=1, the voltage drops to zero and then continues rising. The situation would repeat itself were it not for the conventional cell placed in the same optical path. This cell being excited by the square voltage waveform shown in graph (g) at the time t≥1 introduces a 90 degree rotation of the plane of polarized light which illuminates the cells 1, 2 and 3. As a result the cells 1 and 3 remain dark and the cell 2 remains white but as the saw-tooth

voltage is increasing a white area on the left side of the cell 1 and 3 and the dark area of the cell 2 begins to grow, as shown in graph (d). Following this reasoning for $t=2$ and $t \geq 2$ in graph (e) it is seen that the white and dark areas would shift and move in a wave-like manner animating a flow movement of the image depicted on the screen 12.

While the preferred embodiments of the inventions have been explained and illustrated it will be appreciated that the invention is not restricted to these specific forms but it may consist of further embodiments as a result of adding or omitting some of its elements or combining or varying these forms and is of broader scope as defined in the Claims.

Claims

The embodiments of the invention in which an exclusive property of privilege is Claimed are defined as follows:

1) A display device comprising
   i) A light source
   ii) At least one electro-optical cell illuminated from said light source consisting of at least two walls, at least one being transparent and having at least one surface fixed in slanted orientation with respect to a surface of the other wall, said slant having a constant, a continuously or a discontinuously variable angle in the direction of at least one spatial coordinate, said walls being spaced from each other by means of spacers or side-walls to create an internal sealed volume filled up by a compound responding to an electrical field as required for the operation of said cell, said two walls having conductive electrodes, at least one being transparent, said electrodes being deposited or attached to said walls on at least a part of said surfaces, said electrodes being covered with at least one layer of suitable material as required for the operation of said cell, said electrodes being connected to a voltage source, said source generating a voltage that creates an electric field in said compound and said layers between the electrodes.
2) A display device as described in Claim 1, further comprising a light reflector for performing any one or a combination of the functions of reflecting, enhancing, spectrally modifying, partly transmitting and diffusing the light from said light source, said reflector having a reflecting exterior surface facing towards the viewer, parallel to the interior most wall surface of said cell facing away from the viewer in its operative condition.
3) A display device as described in Claim 1 further comprising a first linear polariser parallel to the interior most wall surface of said cell facing away from the viewer.
4) A display device as described in Claim 3 further comprising

a light reflector parallel to the interior most surface of said first polariser.

5) A display device as described in Claim 3 further comprising a second linear polariser parallel to the exterior most wall surface of said cell facing the viewer in its operating condition, consisting of a sheet having at least one suitably oriented polariser section, said second polariser being oriented at a suitable angle with respect to the first polariser.

6) A display device as described in Claim 5 further comprising a light reflector parallel to the interior most surface of the first linear polariser.

7) A display device as described in Claim 5 further comprising an optical retardation plate placed in between the interior surface of said second linear polariser and exterior surface of the exterior wall of said cell.

8) A display device as described in Claim 7 further comprising a light reflector parallel to the interior most surface of said device.

9) A display device as described in Claim 5 but without the first polariser, comprising in addition parallel to its interior most surface and in the same optical path a conventional twisted or supertwisted nematic liquid crystal display device, the exterior polariser of said conventional display device being a chromatic polariser, said two display devices connected each to one of the outputs of a voltage source, said voltage source capable of independent control of said two display devices.

10) A display device as described in Claim 9 further comprising a light reflector parallel to the interior most surface of said conventional display device.

11) At least two display devices as described in Claim 5, but without the first polariser, side by side, the second polariser on the second device being turned 90 degrees with respect to the second polariser of the first device, said two display devices having their electrodes connected in parallel and excited by a suitable voltage waveform from

the first output of the voltage source, said two display devices comprising in addition a conventional twisted or supertwisted nematic liquid crystal display device but without the second polariser, in the same optical path and parallel to the interior most surfaces of said two display devices, said conventional display device excited by another suitable voltage waveform from the second output of said voltage source.

12) A combination of display devices as described in Claim 11 comprising in addition a light reflector parallel to the interior most surface of said conventional display device.

13) At least two display devices as described in Claim 7, but without the first polariser, side by side, the second polariser of the second device being turned 90 degrees with respect to the second polariser of the first device, said two display devices having their electrodes connected in parallel and excited by a suitable voltage waveform from the first output of the voltage source, comprising in addition a conventional twisted or supertwisted nematic liquid crystal display device but without the second polariser, in serial arrangement and in the same optical path and parallel to the interior most surfaces of said two display devices, said conventional display device and excited by another suitable voltage waveform from the second output of said voltage source.

14) A combination of display devices as described in Claim 13 comprising in addition a light reflector parallel to the interior most surface of said conventional display device.

15) A first display device as in Claim 5, but without the first polariser in which the second polariser and the conductive electrode deposited on the exterior wall consist of at least two sections, insulated from each other and separately excited by different values of a suitable voltage waveform from the first output of the voltage source, the second polariser of the second section being turned by 90 degrees with respect to the second polariser in the first section, comprising in addition a conventional

twisted or supertwisted nematic liquid crystal display device without the second polariser, said conventional device placed in the same optical path and parallel to the interior most surface of said first display device and exited by a suitable voltage waveform for a second output of the voltage source.

16) A combination of display devices as described in Claim 15 comprising in addition a light reflector parallel to the interior most surface of said conventional display device.

17) A first display device as in Claim 7, but without the first polariser in which the second polariser and the conductive electrode deposited on the exterior wall consist of at least two sections, insulated from each other and separately excited by different values of a suitable voltage waveform from the first output of the voltage source, the second polariser of the second section being turned by 90 degrees with respect to the second polariser in the first section, comprising in addition a conventional twisted or supertwisted nematic liquid crystal display device without the second polariser, said conventional device placed in the same optical path and parallel to the interior most surface of said first display device and exited by a square voltage waveform for a second output of the voltage source.

18) A combination of display devices as described in Claim 17 comprising in addition a light reflector parallel to the interior most surface of said conventional display device.

19) A display device as described in any one of the Claims 1 to 18 further comprising a protective, masking or image carrying transparent sheet or screen parallel to the exterior most surface of said display devices facing the viewer.

20) A display device as described in Claim 19 in which said electro-optical compound and electrode surface covering layers are those of a twisted nematic liquid crystal display device.

21) A display device as described in Claim 19 in which said

electro-optical compound and electrode surface covering layers are those of a supertwisted nematic liquid crystal device.

22) A display device as described in Claim 19 in which said electro-optical compound and electrode surface covering layers are those of a Dynamic Scattering Liquid Crystal Display Device.

23) A display device as described in Claim 19 in which said electro-optical compound and electrode surface covering layers are those of a Dichroic Dye Liquid Crystal Display Device.

24) A display device as described in Claim 19 in which said electro-optical compound and electrode surface covering layers are those of a Liquid Crystal Display with an external retardation plate device.

25) A display device as described in Claim 19 in which said electro-optical compound and electrode surface covering layers are those of a Guest-Host Liquid Crystal Display Device.

26) A display device as described in Claim 19 in which said electro-optical compound and electrode surface covering layers are those of a Dye Phase Change Effect Liquid Crystal Display Device.

27) A display device as described in Claim 19 in which said electro-optical compound and electrode surface covering layers are those of a Cholesteric-Nematic Liquid Crystal Display Device.

28) A display device as described in Claim 19 in which said electro-optical compound and electrode surface covering layers are those of a Smectic Liquid Crystal Display Device.

29) A display device as described in Claim 19 in which said electro-optical compound and electrode surface covering layers are those of a Electrochromic Display Device.

30) A display device as described in Claim 19 in which said electro-optical compound and electrode surface covering layers are those of a Electrophoretic Liquid Crystal

Display Device.

31) A display device as described in Claim 19 in which said electro-optical compound and electrode surface covering layers are those of a Dipole Suspension Display Device.

32) A display device as described in Claim 19 in which said electro-optical compound and electrode surface covering layers are those of a Florescence activated Display Device, wherein the reflector comprises a florescence plate assembly.

33) A display device as described in Claim 19 in which said electro-optical compound and electrode surface covering layers are those of an AC Electroluminescent Display Device.

34) A display device as described in Claim 19 in which said electro-optical compound and electrode surface covering layers are those of a DC Electroluminescent Display Device.

35) A display device as described in Claim 19 in which said electro-optical compound and electrode surface covering layers are those of an AC Plasma Discharge Display Device.

36) A display device as described in Claim 19 in which said electro-optical compound and electrode surface covering layers are those of a DC Plasma Display Device.

37) A display device as described in Claim 19 in which said electro-optical compound and electrode surface covering layers are those of a Ferroelectric display device.

38) A display device as in any one of Claims 20-37 which forms at least a part of a meter-monitor-indicator.

39) A display device as in any one of Claims 20-37 which forms at least a part of an advertising, exhibition or alerting animated sign or display.

40) A display device as in any one of Claims 20-37 which forms at least a part of a toy or game.

AMENDED CLAIMS

[received by the International Bureau on 24 September 1991 (24.09.91); original claims 1-40 replaced by amended claims 1-39 (11 pages)]

The embodiments of the invention in which an exclusive property of privilege is Claimed are defined as follows:

1) A display device comprising

i) A light source

ii) At least one electro-optical cell illuminated from said light source consisting of at least two walls, at least one being transparent and having at least one surface fixed in slanted orientation with respect to a surface of the other wall, said slant having a constant, a continuously or discontinuously variable angle in the direction of at least one spatial coordinate, said walls being spaced from each other by means of spacers or side-walls to create an internal sealed volume filled up by a compound responding to an electrical field of the type used in electrochromic display devices, said two walls having conductive electrodes, at least one being transparent, said electrodes being deposited or attached to said walls on at least a part of said surfaces, said electrodes being covered with at least one layer of suitable material as required for the operation of said electrochromic display device, said electrodes being connected to a voltage source, said source generating a voltage that creates an electric field in said compound and said layers between the electrodes.

2. A display device as described in Claim 1 in which said compound and said layer of suitable material covering said electrodes are of the type as required for the operation of a electrophoretic display device.

3. A display device as described in Claim 1 in which said compound and said layer of suitable material covering said electrodes are of the type as required for the operation of a Dipole Suspension Display Device.

4. A display device as described in Claim 1 in which said compound and said layer of suitable material covering said electrodes are of the type as required for the operation of a Florescence activated Display Device, wherein the reflector comprises a florescence plate assembly.

5. A display device as described in Claim 1 in which said compound and said layer of suitable material covering said electrodes are of the type as required for the operation of an AC Electroluminescent Display Device.

6. A display device as described in Claim 19 in which said compound and said layer of suitable material covering said electrodes are of the type as required for the operation of a DC Electroluminescent Display Device.

7. A display device as described in Claim 1 in which said compound and said layer of suitable material covering said electrodes are of the type as required for the operation of an AC Plasma Discharge Display Device.

8. A display device as described in Claim 1 in which said compound and said layer of suitable material covering said electrodes are of the type as required for the operation

of a DC Plasma Discharge Display Device.

9. A display device as described in Claim 1 in which said compound and said layer of suitable material covering said electrodes are of the type as required for the operation of a Dichroic Dye Liquid Crystal Display Device.

10. A display device as described in Claim 1 in which said compound and said layer of suitable material covering said electrodes are of the type as required for the operation of a Guest-Host Liquid Crystal Display Device, comprising in addition one polariser parallel and adjacent to one outer wall surface of said cell.

11. A display device as described in Claim 1 in which said compound and said layer of suitable material covering said electrodes are of the type as required for the operation of a Dynamic Scattering Liquid Crystal Display Device.

12. A display device as described in Claim 1 in which said compound and said layer of suitable material covering said electrodes are of the type as required for the operation of a Dye Phase Change Effect Liquid Crystal Display Device.

13. A display device as described in Claim 1 in which said compound and said layer of suitable material covering said electrodes are of the type as required for the operation of a Cholesteric-Nematic Liquid Crystal Display Device.

14. A display device as described in Claim 1 in which said compound and said layer of suitable material covering said electrodes are of the type as required for the operation of a Smectic Liquid Crystal Display Device.

15. A display device as described in Claim 1 in which said compound and said layer of suitable material covering said electrodes are of the type as required for the operation of a Ferroelectric display device.

16. A display device as described in any one of Claims 1 to 15, further comprising a light reflector for performing any one or a combination of the functions of reflecting, enhancing, spectrally modifying, partly transmitting and diffusing the light from said light source, said reflector having an exterior surface facing towards the viewer, parallel to the interior most wall surface of said display device facing away from the viewer in its operative condition.

17. A display device comprising

i) A light source

ii) At least one electro-optical cell illuminated from said light source consisting of at least two walls, at least one being transparent and having at least one surface fixed in slanted orientation with respect to a surface of the other wall, said slant having a constant, a continuously or discontinuously variable angle in the direction of at least one spatial coordinate, said walls being spaced from each other by means of spacers or side-walls to create an internal sealed volume filled up by a compound responding to an electrical field, of the type as required for the operation of a Twisted (TNLC) or Super Twisted Nematic Liquid Crystal Cell

(STNLC), said two walls having conductive electrodes, at least one being transparent, said electrodes being deposited or attached to said walls on at least a part of said surfaces, said electrodes being covered with at least one layer of suitable material as required for the operation of said TNLC or STNLC cell, said electrodes being connected to a voltage source, said source generating a voltage that creates an electric field in said compound and said layers between the electrodes.

iii) an interior linear polariser parallel to the interior most wall surface of said cell facing away from the viewer.

iv) an exterior linear polariser parallel to the exterior most wall surface of said cell facing the viewer in its operating condition, consisting of a sheet having at least one suitably oriented polariser section, said exterior polariser being oriented at a suitable angle with respect to the first polariser.

18. A display device comprising

i) A light source

ii) At least one electro-optical cell illuminated from said light source consisting of at least two walls, at least one being transparent and having at least one surface fixed in slanted orientation with respect to a surface of the other wall, said slant

having a constant, a continuously or discontinuously variable angle in the direction of at least one spatial coordinate, said walls being spaced from each other by means of spacers or side-walls to create an internal sealed volume filled up by a compound responding to an electrical field, of the type as required in a Twisted (TNLC) or Super Twisted Nematic Liquid Crystal Cell (STNLC), said two walls having conductive electrodes, at least one being transparent, said electrodes being deposited or attached to said walls on at least a part of said surfaces, said electrodes being covered with at least one layer of suitable material as required for the operation of said TNLC or STNLC cell, said electrodes being connected to a voltage source, said source generating a voltage that creates an electric field in said compound and said layers between the electrodes.

iii) an exterior linear polariser parallel to the exterior most wall surface of said cell facing the viewer in its operating condition, consisting of a sheet having at least one suitably oriented polariser section, said second polariser being oriented at a suitable angle with respect to the first polariser.

19. A display device as described in Claim 17 further comprising an optical retardation plate placed in

between the interior surface of said exterior linear polariser and exterior surface of the exterior wall of said cell facing the viewer.

20. A display device as described in Claims 17, 18 or 19 further comprising a light reflector for performing any one or a combination of the functions of reflecting, enhancing, spectrally modifying partly transmitting and diffusing the light from said light source, parallel to the interior most surface of said device facing the viewer.

21. A display device as described in Claim 18 comprising in addition parallel to its interior most surface and in the same optical path a conventional twisted or supertwisted nematic liquid crystal display device, the exterior polariser of said conventional display device being a chromatic polariser, said two display devices connected each to one of the outputs of a voltage source, said voltage source capable of independent control of said two display devices.

22. A display device as described in Claim 21 further comprising said light reflector parallel to the interior most surface of said conventional display device facing away from the viewer.

23. At least two display devices as described in Claim 18, side by side, the exterior polariser on the exterior device being turned 90 degrees with respect to the exterior polariser of the first device, said two display devices having their electrodes connected in parallel

sections, insulated from each other and separately excited by different values of a suitable voltage waveform from the first output of the voltage source, the exterior polariser of the second section being turned by 90 degrees with respect to the exterior polariser in the first section, further comprising an optical retardation plate placed in between the interior surface of said exterior polariser and exterior surface of the exterior wall of said cell, comprising in addition a conventional twisted or supertwisted nematic liquid crystal cell and an interior polariser, said conventional device placed in the same optical path and parallel to the interior most surface of said display device and exited by a square voltage waveform for a second output of the voltage source.

30. A display device as described in Claim 29 comprising in addition said light reflector parallel to the interior most surface of said conventional display device.

31. A display device as in any one of Claims 1-15, 17-19 and 21-30 which forms at least a part of a meter-monitor-indicator.

32. A display device as in any one of Claims 1-15, 17-19 and 21-30 which forms at least a part of an advertising, exhibition or alerting animated display.

33. A display device as in any one of Claims 1-15, 17-19 and 21-30 which forms at least a part of a toy or game.

34. A display device as in any one of Claim 16 which forms at least a part of a meter-monitor-indicator.

35. A display device as in any one of Claim 16 which forms at least a part of an advertising, exhibition or alerting animated display.

36. A display device as in any one of Claim 16 which forms at least a part of a toy or game

37. A display device as in any one of Claim 20 which forms at least a part of a meter-monitor-indicator.

38. A display device as in any one of Claim 20 which forms at least a part of an advertising, exhibition or alerting animated display.

39. A display device as in any one of Claim 20 which forms at least a part of a toy or game..

and excited by a suitable voltage waveform from the first output of the voltage source, said two display devices comprising in addition a conventional twisted or supertwisted nematic liquid crystal cell and an interior polariser, in the same optical path and parallel to the interior most surfaces of said two display devices, said conventional display device excited by another suitable voltage waveform from the second output of said voltage source.

24. A display device as described in Claim 23, further comprising said light reflector parallel to the interior most surface of said conventional display device facing away from the viewer.

25. At least two display devices as described in Claim 18, side by side, the exterior polariser of the second device being turned 90 degrees with respect to the exterior polariser of the first device, further comprising an optical retardation plate placed in between the interior surface of said exterior polarisers and exterior surface of the exterior wall of said cells, said two display devices having their electrodes connected in parallel and excited by a suitable voltage waveform from the first output of the voltage source, comprising in addition a conventional twisted or supertwisted nematic liquid crystal cell and an interior polariser in serial arrangement and in the same optical path and parallel to the interior most surfaces of said two display devices, said conventional display device

and excited by another suitable voltage waveform from the second output of said voltage source.

26. A display device as described in Claim 25, further comprising said light reflector parallel to the interior most surface of said conventional display device facing away from the viewer.

27. A display device as in Claim 18, in which the exterior polariser and the conductive electrode deposited on the exterior wall consist of at least two sections, insulated from each other and separately excited by different values of a suitable voltage waveform from the first output of the voltage source, the exterior polariser of the second section being turned by 90 degrees with respect to the exterior polariser in the first section, comprising in addition a conventional twisted or supertwisted nematic liquid crystal cell and an interior polariser, said conventional device placed in the same optical path and parallel to the interior most surface of said display device and exited by a suitable voltage waveform for a second output of the voltage source.

28. A display device as described in Claim 27, further comprising said light reflector parallel to the interior most surface of said conventional display device facing away from the viewer.

29. A display device as in Claim 18, in which the exterior polariser and the conductive electrode deposited on the exterior wall consist of at least two

STATEMENT UNDER ARTICLE 19

1. Paper by C.P. Lundeman. I consider it of some relevance to this invention. Accordingly claims 1 - 6, 7, 9, and 19 were cancelled and claim 39 changed in the claims as filed.

2. Patent by E. Prior et al. Refers to liquid crystal panels with parallel oriented electrodes and the assembly of said panels. No methods of animating single panels shown. As such it is of the interest as the general state of the art.

3. Patent by Nakada. Achieves a similar end-result as my invention but not by changing purposely the spacing between the two electrodes but by substituting the top conductive electrode by a resistive electrode of varying thickness; the latter being electrically connected to the bottom conductive electrodes; the two thus acting as a voltage divider. Therefore the structure and function is different, but the patent is of interest as the general state of the art. No method of animation is mentioned.

4. Patent abstract of Japan (Matsushita). Structurally different but of general state of the art interest. No method of animation is mentioned.

In view of the search report and the above comments, the amended claims 1 - 39 have been narrowed down and restricted to specific cases by including only the dependent claims that were not objected to in the search report. The amended claims do not introduce any new material that was not mentioned in the disclosure, the claims and the drawings, as filed.

Accordingly as mentioned above the filed claims 1 - 6, 7, 9, and 19 were cancelled. The more specified and restricted claims 20-23 and 25 - 37 as filed have been moved forward and are replaced by the amended claims 1 - 22, and claim 24 replaced by the amended claim 19. Claims 11 - 18 as filed are replaced by the amended claims 23 - 30 basically almost without change of wording. Claims 38 - 40 as filed were replaced by 31 - 39, the additional claims were introduced to avoid the problems of multiple dependency. Claim 18 is new and was introduced to simplify the original wording of filed claims 11, 13, 15 and 17 now shown as the amended claims 23, 25, 27 and 29.

First and second polariser have been renamed "interior" and "exterior" polariser respectively.*

* Please note these corrections on the enclosed pages 8 and 9 of the disclosure for substitution.

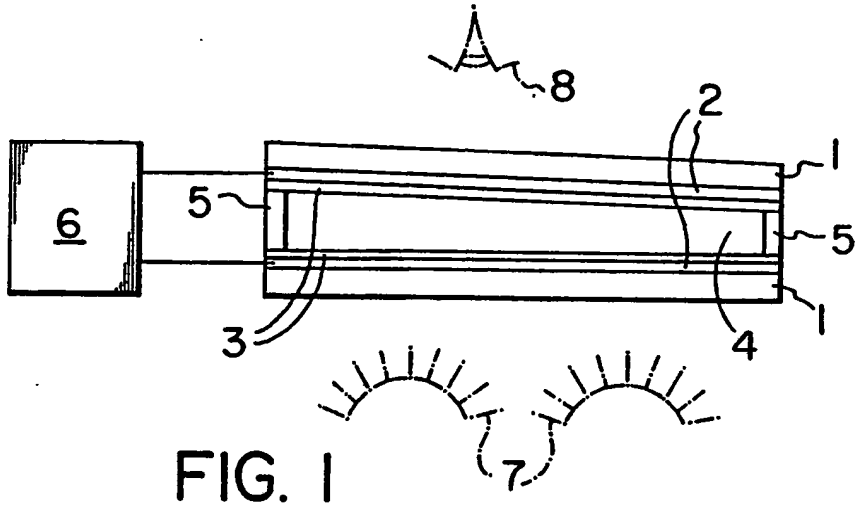


FIG. 1

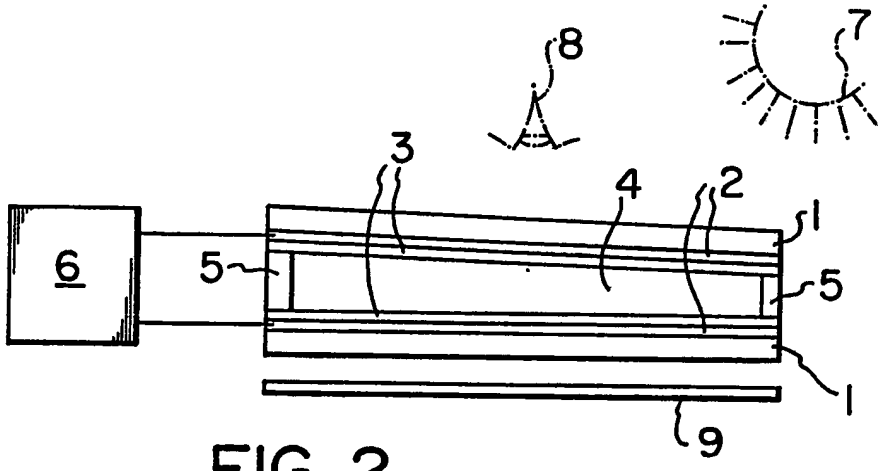


FIG. 2

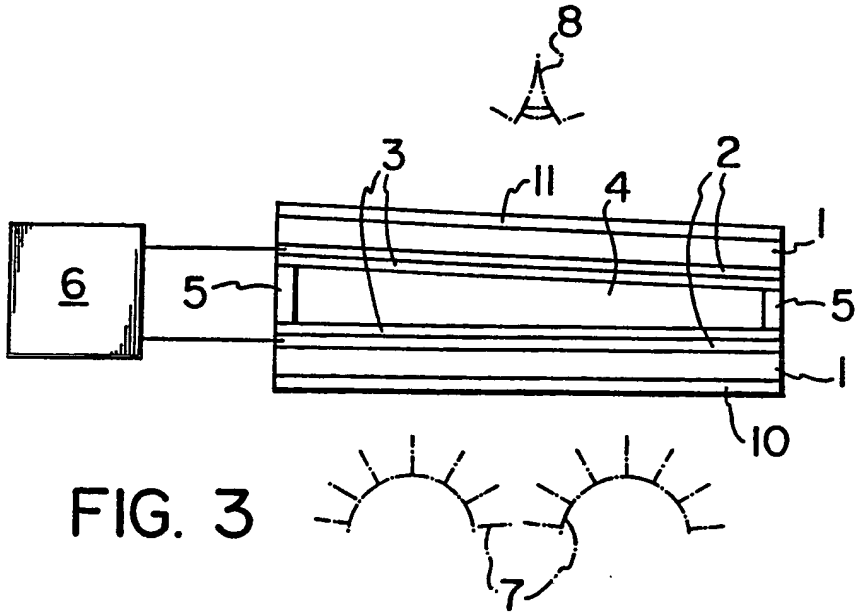


FIG. 3

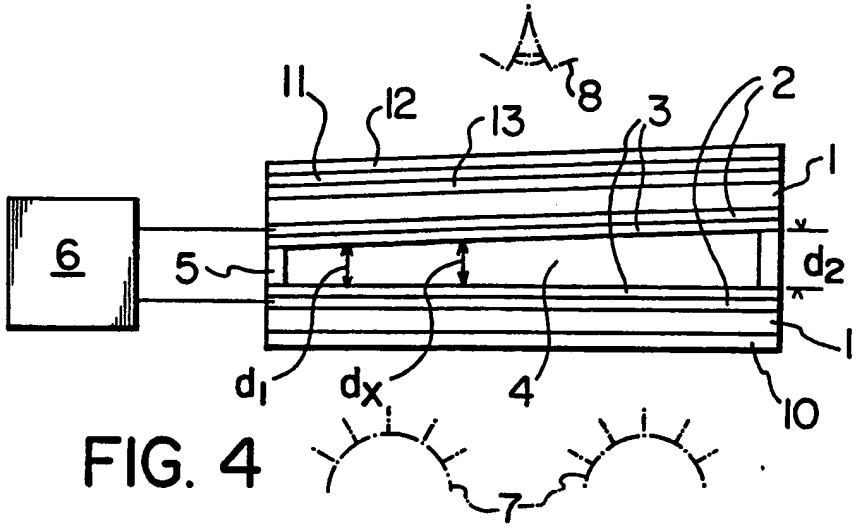


FIG. 4

FIG. 5

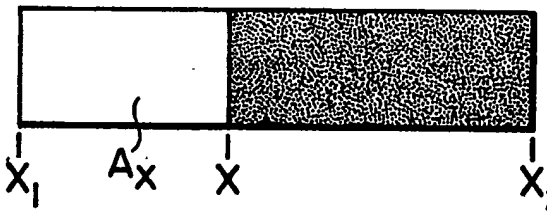


FIG. 6

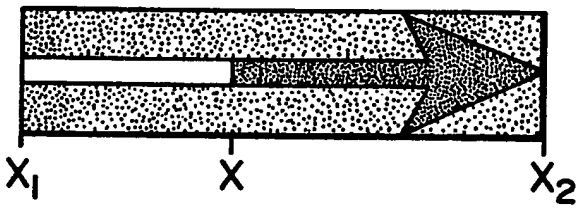
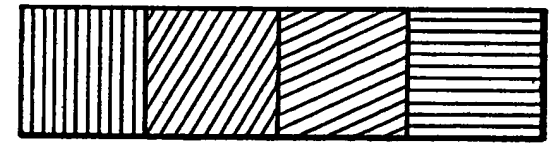


FIG. 7



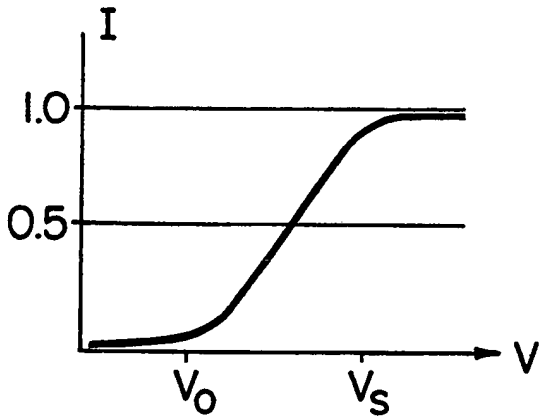


FIG. 8

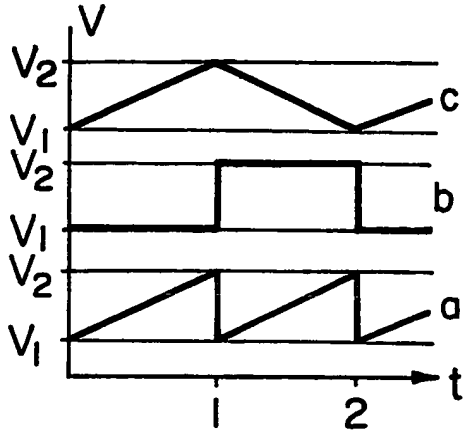


FIG. 9

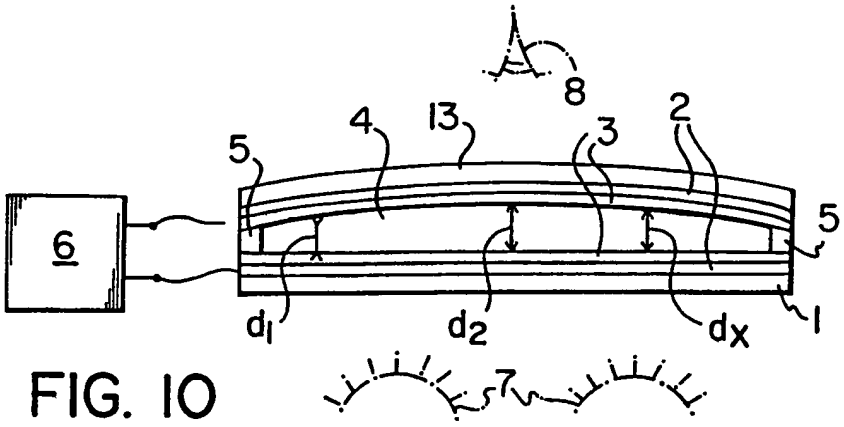


FIG. 10

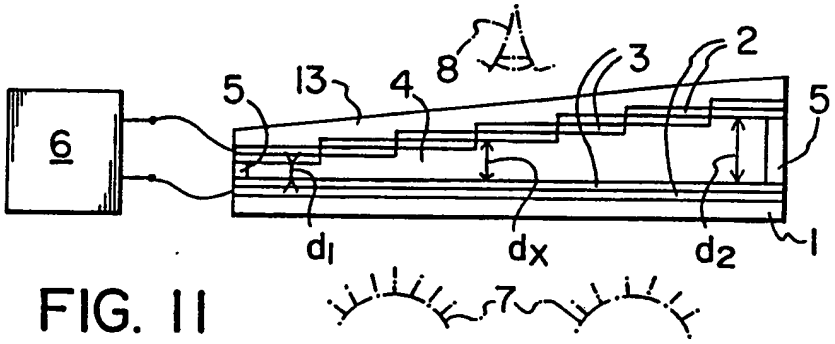


FIG. 11

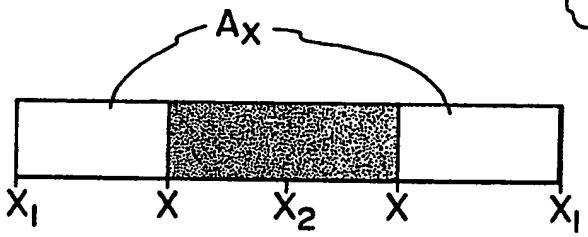


FIG. 12

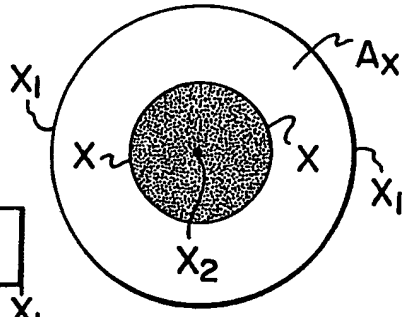


FIG. 13

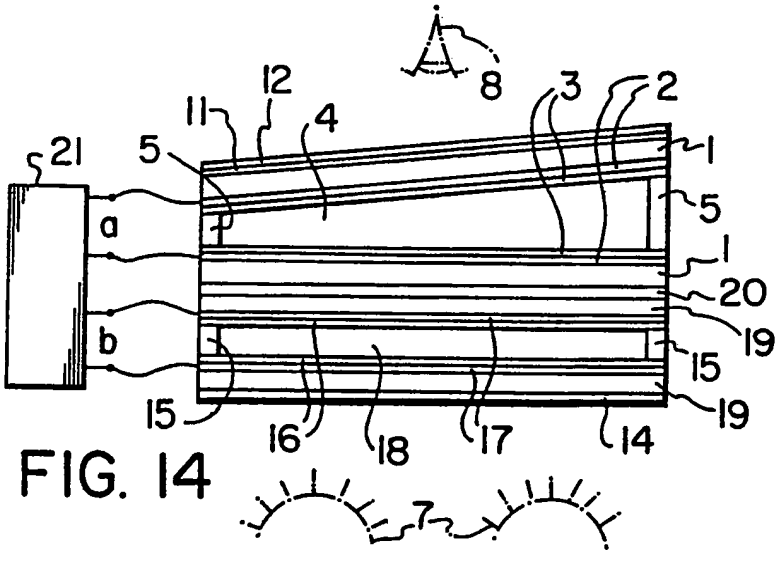


FIG. 14

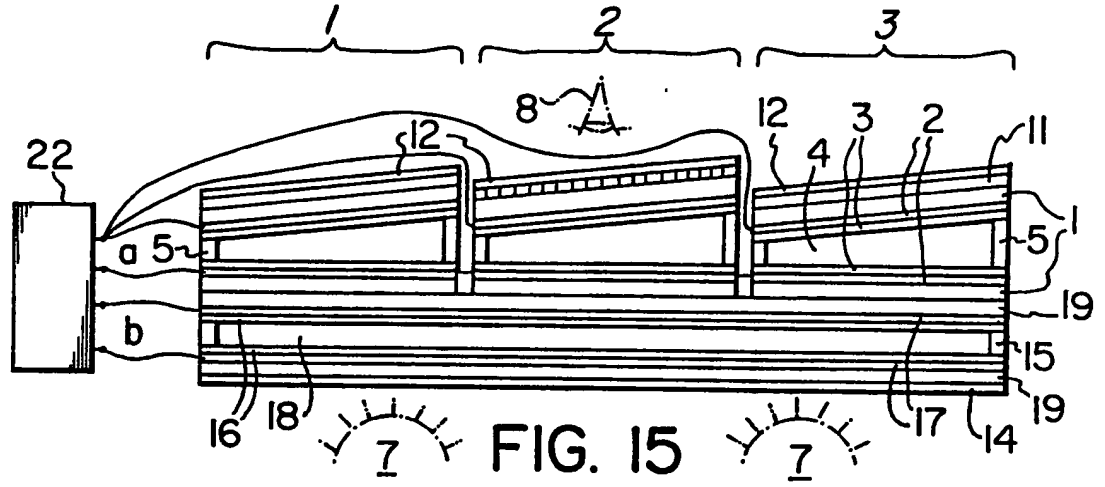


FIG. 15

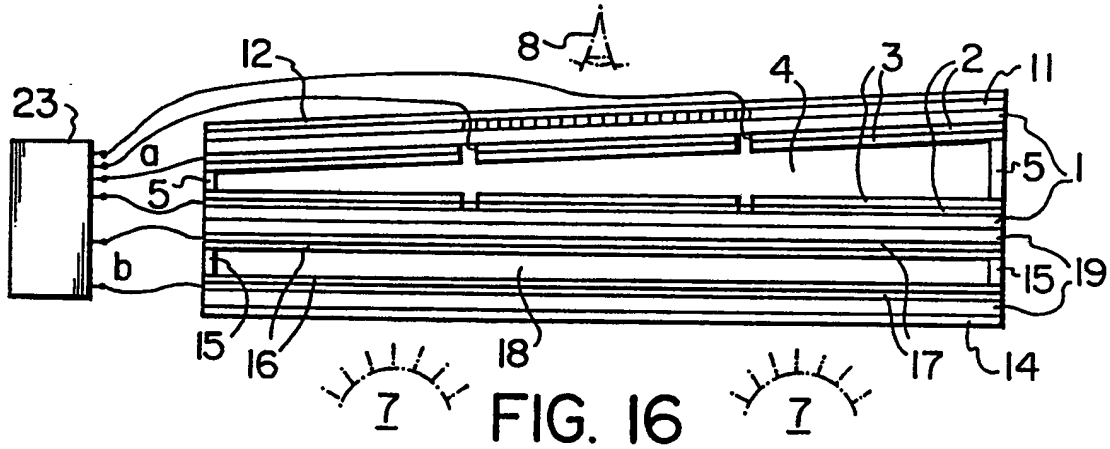


FIG. 16

FIG. 17a  t=0

FIG. 17b  t=0.5

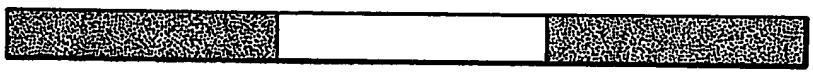
FIG. 17c  t≤1.0

FIG. 17d  t=1.5

FIG. 17e  t≥2.0

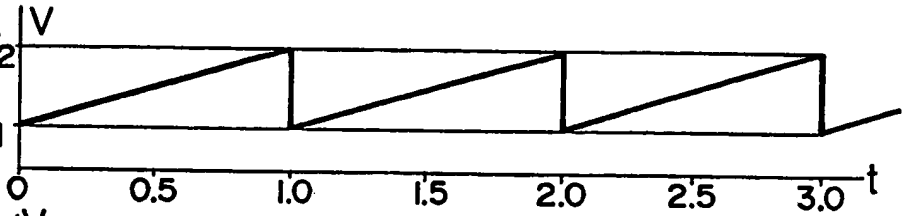
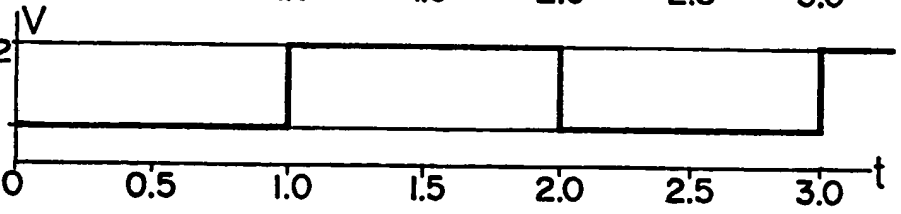
FIG. 17f 

FIG. 17g 

INTERNATIONAL SEARCH REPORT

International Application No PCT/CA 91/00068

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[5]: G 02 F 1/1333, 1/1347, G 01 D 7/00, G 01 R 13/40, G 01 F 19/12, A 63 F 9/06

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[5]	G 02 F, G 01 D, G 01 R, G 09 F, A 61 F

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	IBM Technical Disclosure Bulletin, vol. 15, no. 4, September 1972 (US) C.P. Ludeman et al.: "Liquid-crystal cell having nonuniform thickness", pages 1349-1350, see the whole article	1-6
Y		5,7,9,19, 39
Y	GB, A, 1457531 (E. PRIOR) 1 December 1976 see page 1, line 16 - page 2, line 11	5,7,9,19, 39
X	US, A, 4112361 (NAKADA) 5 September 1978 see column 5, line 41 - column 7, line 38	1
A		38
A	Patent Abstracts of Japan, vol. 12, no. 140 (P-696)(2987), 28 April 1988 & JP, A, 62-262022 (MATSUSHITA) 14 November 1987	1

* Special categories of cited documents: [10]

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
5th June 1991	30. 07. 91
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	miss T. MORTENSEN

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. CA 9100068 SA 45195

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 16/07/91
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB-A- 1457531	01-12-76	None	
US-A- 4112361	05-09-78	JP-A- 52101081	24-08-77
		JP-A- 52109978	14-09-77
		JP-A- 51144273	11-12-76

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